PB85-173607

# Application of Lightweight Composite Materials to Naval Weapons Systems


Virginia Polytechnic Inst. and State Univ.
Blacksburg


Prepared for

Naval Ship Systems Engineering Station
Philadelphia, PA




Feb 85





U.S. Department of Commerce
National Technical Information Service
NTIS




48295

PB85-173607

# COLLEGE OF ENGINEERING

# VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

BLACKSBURG, VIRGINIA

# BIBLIOGRAPHIC INFORMATION

PB85-173607

Application of Lightweight Composite Materials to Naval Weapons Systems.

Feb 85

by W. W. Stinchcomb, and K. L. Reifsnider.

PERFORMER: Virginia Polytechnic Inst. and State Univ., Blacksburg. Coll. of Engineering.
VPI-E-85-7

SPONSOR: Naval Ship Systems Engineering Station, Philadelphia, PA.
Interim rept.

Sponsored by Naval Ship Systems Engineering Station, Philadelphia, PA.

The objective of the present program is to conduct a comprehensive study of the possibility that composite materials can be applied to Naval weapons systems. The particular system addressed in this study is a weapons elevator door. Specific attention is given to (a) weight savings, (b) structural design, (c) shipboard requirements, and (d) component testing.

KEYWORDS: *Composite materials, *Weapon systems.

Available from the National Technical Information Service, SPRINGFIELD, VA. 22161

PRICE CODE: PC A03/MF A01

College of Engineering
Virginia Polytechnic Institute and State University
Blacksburg, Virginia

VPI-E-85-7 February 1985

Application of Lightweight Composite Materials to
Naval Weapons Systems

Interim Report

Wayne W. Stinchcomb
Kenneth L. Reifsnider

Materials Response Group
Department of Engineering Science and Mechanics
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061-4899

Submitted to:
Naval Ship Systems Engineering Station
Philadelphia, PA 19112
Contract Monitor:
Joseph Mislan
Code 073, Building 73

2

## Introduction

Composite structures are being used in a large number of engineering components on a wide range of devices, machines, and vehicles. Although the primary advantages of such materials are high ratios of strength to weight and stiffness to weight, a number of other features can be designed into the structure to achieve specific design requirements such as dimensional stability, heat conductivity, corrosion resistance, and impact damage tolerance. New manufacturing and repair technologies, combined with high performance characteristics, offer attractive long-term cost effective potentials.

The objective of the present program is to conduct a comprehensive study of the possibility that composite materials can be applied to Naval weapons systems. The particular system addressed in this study is a weapons elevator door. Specific attention is given to (a) weight savings, (b) structural design, (c) shipboard requirements, and (d) component testing. Work on items (a), (b), and (c) has been completed and work on item (d) is now being conducted. Details of the component testing program will be discussed later in this report.

The scope of the investigation includes: (a) the identification of experts with a broad range of expertise and experience to assist in the design and manufacture of weapons elevator doors; (b) the organization of a working group composed of these experts to assess the state of technology related to composite structures, determine the major design parameters to be addressed in the design, fabrication, and performance of an elevator door; and (c) submit design concepts for evaluation.

KLR:NAVSSESFIN

The scope of the program was extended to include fabrication of five composite door panels which were provided by three industrial organizations at no cost to the Navy. The five panels are currently being tested as an extension of the original contract. The test results and evaluation will be reported in the final report.

## Working Groups

Information on the objectives, scope, and requirements of the program was provided to organizations with interest and expertise in designing composite structures, supplying materials, and manufacturing composites hardware. These organizations were invited to send representatives to the initial meeting of the Working Group on Application of Composite Materials to Naval Weapons Systems held at Virginia Tech, 26 and 27 July, 1983. Subsequent meetings were held at David Taylor Naval Ship Research and Development Center (DTNSRDC) in Annapolis, Maryland on 7 and 8 September, 1983 and at DTNSRDC, Carderock, Maryland on 9 and 10 January, 1984. On-board visits to the Nimitz (CVN 68) and Kennedy (CV 67) provided opportunities for the working groups to see the requirements for and operation of the weapons systems elevator doors. Summaries of the three meetings of the working groups are given in Appendix A. Names of participating organizations and their representatives are given in Appendix B. Twenty-seven people, representing eighteen organizations, attended the working group meetings and participated in the technical discussions.

## Design Criteria for Elevator Door Concepts

Following the second meeting of the working group, held at DTNSRDC -- Annapolis, a list of design criteria was established and distributed to the participants. These criteria were divided into two categories: (A) Essential Criteria and (B) Other Important Criteria, as shown in Appendix C. Organizations which desired to submit design concepts were given the opportunity to do so with the understanding that the designs would be evaluated according to the criteria shown in Appendix C.

## Evaluation of Design Concepts

Design concepts were submitted for evaluation by five organizations and a sixth concept was submitted after the evaluation. The evaluations were conducted by Joe Mislan (NAVSSES), Ken Reifsnider (Virginia Tech) and Wayne Stinchcomb (Virginia Tech) under the general categories of Materials System Evaluation and Design Evaluation. Subcategories and ratings are given in Appendix D. All of the designs were based on a skin-core concept to achieve weight savings and facilitate tailorability to achieve other design requirements. This concept places most of the material in the skin to achieve flexural stiffness, uses either a solid or hollow core system to achieve shear stiffness, and utilizes appropriate materials in the skin and core to provide ballistic, thermal, corrosion, etc. protection.

The evaluations were given to each organization which submitted a design concept and were presented to the working group at the third meeting. The evaluations were also reviewed privately and individually with each organization which submitted a design concept. Each of the five organizations was invited to submit a test article, representative

of their design, for evaluation. The invitation was also extended to organizations which did not submit design concepts for evaluation. Three organizations have submitted five test articles for evaluation. Four of the panels were designed and fabricated at no expense to the Navy. The fifth panel, incorporating fiber reinforced metal matrix composite material technology, was supplied by DWA with financial assistance from the Navy. Physical data on the five representative door panels are presented in Appendix E along with pictures of each panel.

## Testing of Elevator Door Panels

The scope of the program was expanded to include testing the five door panels to evaluate behavior under various conditions determined to be important in the design of the door structure. A number of criteria were discussed in the working group sessions. After the second meeting of the working group, two categories of design criteria were formulated as follows (See Appendix C).

A. Essential Criteria -- (1) resistance to water pressure, (2) weight, and (3) fire resistance.

B. Other Important Criteria (no priority order implied) --

- ballistics
- blast
- cost
- durability
- producibility
- shock.

Evaluation of the design concepts showed that the weight of the proposed panels is substantially less than that of conventional door structure designs. The test series was then defined to include the remaining two criteria from the 'essential criteria' category and two criteria from the 'other important criteria' category. Ballistic

protection and shock resistance were selected to complete the proposed test series.

The following tests will be conducted:

1. Mechanical tests to determine the stiffness of the test panels. Three panels (one TRE, one Martin, and the DWA panel) will be simply supported on the edges of the face plates and subjected to a uniform pressure loading perpendicular to the plane of the panel. The maximum pressure will be on the order of 10 psi and should not cause plastic deformation or damage to the panels. Strain at various locations on the non-loaded face of the panel will be measured by strain gages and recorded as a function of applied load. At least eight, 2-element (X-Y) strain gages will be attached to the TRE panel. The protective coating on one Martin panel and the skin construction of the DWA panel will not permit meaningful strain values to be measured. The deflection of the center point will be recorded during load application using an electro-mechanical transducer. The relative stiffnesses of the panels will be determined from the strain and/or deflection vs. pressure data.

   These tests will be conducted in the Panel Test Fixture, Structural Test Laboratory, Martin Marietta Aerospace, Baltimore, Maryland (Fig. 1). Contact person: George Mickolite, (301)338-5423.

2. Fire tests to determine the heat flow characteristics through-the-thickness of the three previously tested panels. These tests will be conducted on three test panels according to ASTM Standard E119 by exposing one side of the panel to a known heat

source and measuring the temperature rise with time on the opposite side of the panel.

These tests will be conducted at AVCO Corporation, Lowell, Massachusetts. Contact person: Joe Missola, (617)454-5370.

3. Ballistic tests to evaluate the resistance of the three panels to penetration by a Cal .50 fragment simulating projectile. The test will determine the projectile velocity $V_{50}$ required for 50 percent probability of penetration of each panel. Complete penetration is determined by perforation of a witness plate.

   The tests will be conducted at the Naval Surface Weapons Center, Dahlgren, Virginia and will be patterned after the U.S. Army Test and Evaluation Comment Test Operations Procedure 2-2-710. Contact person: Lou Caccia, (703)663-8691.

4. Shock tests to determine the suitability of the three door panel structures for use under the effects of severe shock which may be incurred in use due to accident or in use during wartime service.

   These tests will be conducted according to MIL-S-901C (Navy) at NSRDC, Annapolis. Contact person: Gene Camponeschi, (301)267-2165.

5. Mechanical tests to determine strength of the panels. The untested TRE and Martin panels, along with the previously tested DWA panel, will be subjected to uniform pressure loading using the same test set-up as in the stiffness determination tests. The TRE and uncoated Martin panel will be instrumented with at least eight 2-element (X-Y) strain gages. The pressure will be increased and the pressure corresponding to the first failure mode will be

determined. Strains and center point deflection will be measured throughout the loading and used as sentinels of the damage events corresponding to the first failure modes.

These tests will be conducted at the Structural Test Laboratory, Martin Marietta Aerospace, Baltimore, Maryland. Contact person: George Mickolite, (301)?38-5423.

## Test Reports

Each laboratory will submit a written report, including experimental data and a description of the test set-up and precedures, to Virginia Tech. These results will be submitted to the Navy as part of the final report for the project.

## Data and Information Transfer

One of the objectives of the program is to create a system for the transfer of information and data from Virginia Tech to NAVSSES, based on computer-based hardware systems. That objective has been achieved using either the Virginia Tech IBM 3081 mainframe or the Engineering Science and Mechanics Department's Data General MV-3000 Super-mini computer to communicate with the NAVSSES computer via phone lines.

The scheme that has been created is a file transfer method. The process begins in the laboratory where data is generated and stored on a file in an acquisition system (a Canberra Imacs micro-computer in this case). When the file is complete, it is transferred to a file on the IBM mainframe or the Data General Super-mini computer by a data line, or written onto a nine-track tape and carried to the local computers for access. Once the file has been created under the proper userid, it can

be transferred to NAVSSES via dial-up telephone lines. This process has been successfully tested.

At this writing, the matter of reading the file to NAVSSES is unsettled. While the file transfer is not difficult, formatting a file to be read by another device is not always straightforward. However, this is a matter of establishing proper parameters for a specific device and determining the proper control language to adjust or set those parameters.

Contact person: Don J. Bodnar, (703)961-5075, -6535.

Appendix A.

Report of the Working Group on
Application of Composite Materials to Naval Weapons Systems

Meeting No. 1.
July, 1983

As part of a contracted research program sponsored by the NAVSSES monitored by Joe Mislan, a conference on the "Application of Composite Materials to Naval Weapons Systems" was held at Squires Student Center, Virginia Polytechnic Institute and State University on July 26 and 27. 1983. The purpose of the meeting was to assemble a group of technical people representing composite material suppliers, structural manufacturers and designers, and research and development groups who would be potential participants in the design, manufacturing, and testing of an elevator door. Fifteen people attended the meeting, representing various government, industry, and university laboratories. An attendance list is appended to this report.

The program began at 9:00 am, Tuesday, 25 July with introductions and announcements. Joe Mislan (NAVSSES) then began the technical program by discussing the objectives of the overall program of activities associated with the subject activities. He provided a technical perspective for the problems associated with the construction, operation, and maintenance of elevator doors and hatches and related structures on ships. He emphasized the need for standardization of such structures and for improved designs for such standard doors, hatches, and related mechanisms. Wayne Stinchcomb (Virginia Tech) then introduced the specific objectives of the contract research program at Virginia Tech and discussed the immediate goals of the meeting. He

emphasized the need to define the specifications associated with elevator doors, to establish feasible design concepts for such doors with those specifications, to determine a plan for the manufacturing and testing of the specific designs, and to identify people and organizations that wish to be involved in the program. He emphasized that these matters were to be resolved by the end of the subject meeting. A question-answer session followed after which there was an intermission for coffee and pastries.

When the meeting resumed, Joe Mislan and Ted Anderer discussed their development of geodesic space-frame truss structures. The extreme strength-to-weight ratio of such a structure was stressed. Then four videotapes were shown which displayed a variety of doors and hatches (on various ships) in action, as well as various latching and hinging devices. The tapes served to provide an excellent perspective for the meeting and were well received.

The afternoon began with a "Survey of Applications of Metal Matrix Composite Materials to Naval Structures" delivered by Dr. Marlin Kinna (Naval Sea Systems Command), an extremely informative and thorough survey of activities. Bob Crowe (NSRDC - White Oak) followed with a discussion of metal matrix structures associated with armaments. Jim Pooser (Babcock & Wilcox, Lynchburg) discussed a variety of programs and activities and focused on the metal matrix work at their laboratories. Mel Mittnick (AVCO - SMD) presented "A Review of SiC Filament Production and Composites Fabrication Techniques at AVCO Specialty Materials Division". A discussion of "Metal Matrix Composite

Applications to Transport and Fighter Mainframe Structures" by Lockheed (Georgia) was then presented by Steve Moran. The final presentation was made by Richard McLay (GE, Burlington) and included a 16 mm film to demonstrate the successful use of composites for a gun turret structure. The presentations provided an excellent review of technology and activities related to the subject program.

The second day began with a presentation by Ken Reifsnider (Virginia Tech) that described the Center for Composite Materials and Structures at Virginia Tech. Joe Mislan followed with a discussion of the specifications and requirements associated with elevator doors. It was emphasized that several of these specifications are not yet established in complete form, especially those associated with fire and blast requirements. An open discussion followed in which four major design concepts were established: a plate design, a hollow plate design, an open core-sandwich skin design, and a skin-core design. Materials for each design were discussed and advantages and concerns associated with each were established.

The meeting ended with a discussion of future plans. It was agreed to try to meet again during the first week in September at which time specific plans for the design and manufacturing of the test panel for the subject program will be set. A questionaire was circulated to the participants to establish their level of interest in continued activities and to receive their comments regarding the meeting. Comments received so far have been very enthusiastic and positive.

A4

Report of the Working Group on
Application of Composite Materials to Naval Weapons Systems

Meeting No. 2
September, 1983

The second meeting of the Ship Structures Committee was held on 7-9 September 1983. The first two days of the meeting were hosted by the Advanced Composites group of the David Taylor Naval Ship Research and Development Center, Annapolis, MD. The meeting was arranged by Eugene T. Camponeschi, Jr., a materials engineer at that Center. The third day of the meeting was held in Norfolk, VA for the purpose of touring the U.S.S. Kennedy to observe elevator doors, hatches, and other ship structures. The meeting was attended by 22 people representing various industries (10), government laboratories (3), and universities (1). An agenda and attendance list for that meeting are appended to this summary.

The meeting began on 7 September with a review of activities at the first meeting (held at Virginia Tech on July 26-27, 1983). Joe Mislan (NAVSSES) then provided an update on the specifications for the standard elevator door. The four primary requirements for water load, blast, fire, and shock were specifically addressed. A discussion of the specifications followed during which additional considerations such as ballistic resistance, producibility, cost/weight savings, quality control, weight train criteria, material and structural trade-offs, EMI protection, long-term behavior (including creep), surface finishes, and maintenance were discussed.

During the afternoon of 7 September presentations were made by several of the attendees. John Kenney (Project Engineers Company)

presented data and information about their product called Pyramidal Truss Core. Ron Carlson (Babcock and Wilcox, Barberton) presented a discussion of the "Application of Composite Materials to Naval Weapons Systems". George Spaar (Ciba-Geigy, Ardsley, NY) discussed several panel constructions including Fiberlam, a product developed for aircraft floors. Mel Mittnik (AVCO - SMD) discussed various silicon carbide based composite materials manufactured by AVCO. Dick McLay (GE, Burlington) presented information about the construction of a composite turret for a Gatling gun. D. C. Agarwal (Cabot Corp.) described the mechanical, thermal, and chemical (corrosion) properties of Ferralium. Milt Critchfield completed the program with a discussion of a well developed activity at his laboratory (DTNSRDC - Carderock) which will result in several new concepts for ship topside structures.

The morning of the second day was devoted almost entirely to a vigorous discussion of design concepts. A matrix comparison of material (panel) weight, cost, and system weight and cost was generated for several "major contender" concepts. Ballistic and blast requirements were discussed. A major topic of discussion was producibility, especially for "new concept" designs. The development of new designs which involve new (especially composite) materials compared to the development of new designs involving conventional or "off-the-shelf" materials was compared and contrasted.

A tentative schedule for continuing activity was set. It was decided to request that all information, concept descriptions, statements of interest, cost information, descriptions of capabilities,

etc. be submitted to the Virginia Tech program leaders by 31 October 1983. After that date, concepts will be rated (by criteria discussed) and an order of preference determined. At the next meeting (in mid November) the final plans for the acquisition of 2 ft. by 2 ft. "test-of-concept" panels will be made, to include the makeup of groups that may form for purposes of design and construction of such panels, as well as for the testing of the panels. A schedule for obtaining and testing the panels will also be determined at that time.

The third day of the meeting was devoted to a tour of the U.S.S. John F. Kennedy (CV 67) at the Naval Base in Norfolk, VA to observe doors and hatches on that carrier. The tour was extremely informative and enjoyable.

A7

Report of the Working Group on
Application of Composite Materials to Naval Weapons Systems

Meeting No. 3
January 1984

We are including in this mailing some of the information we shared during the recent meeting at NSRDC-Carderock. A brief summary of the progress reported at that meeting follows.

1. Five design concepts were received and evaluated prior to the meeting. A sixth concept has recently been submitted. All designs achieve weight savings compared to the existing metal elevator door assembly: however, it is not possible at this time to estimate engineering values of weight savings because the insulation, blast, and fragmentation requirements need to be addressed more completely.

2. Although improvements need to be made in some of the concepts, resistance to mechanical deformation due to water pressure and corrosion resistance appear to be achievable through design innovation and material selection.

3. Data from fire tests at Avco show that over a 30 minute test, temperatures on the unexposed side of several test panels were significantly lower than on the unexposed side of HY-80 steel panels.

4. There are indications that composite door structures can be more easily and efficiently maintained than the present doors. However, specific information on repair procedures, for example, has not been included in the design concept phase of the program.

5. Preliminary life cycle cost estimates, based on weight savings, design modularity, and perceived maintenance efficiency, suggest that the composite door structures can be cost effective.

6. Potential suppliers of the 2 ft. by 2 ft. test panels do not foresee problems in manufacturing these panels. Some suppliers said fabrication of the full scale door structure could be a problem.

7. Issues that need to be more completely addressed in the design and fabrication of the test panels are fire protection and insulation, blast protection, fragment penetration resistance, and shock.

8. The test procedure will be formulated and distributed to all participants.

9. A target date of April 1, 1984 has been set for submission of the test panels.

We appreciate your continued enthusiastic interest in and support of this program. Please let us know how we can assist you during the next phase of the program. If you intend to supply a panel for evaluation please feel free to call us concerning the details of the test procedure; it would also help us to have some idea of your delivery schedule so that we can plan our test schedule.

Appendix B.

Working Group Participants

Application of Composite Materials to Naval Weapons Systems

| Name | Organization & Address | Telepnone No. |
|---|---|---|
| AGARWAL, D. C. | CABOT CORPORATION<br>Kokomo, IN 46901 | (317) 456-6031 |
| ANDERER, Ted | NAVSSES Code 073B<br>Philadelphia Naval Base<br>Philadelphia, PA 19112 | (215) 755-3605<br>-3818 |
| BOND, John | Managing Director<br>TRE ASTECH MARINE PRODUCTS<br>TRE Corporation<br>800 Hillcrest Rd., Suite 5<br>Mobile, AL 36609 | (205) 343-5888 |
| CAMPONESCHI, Gene | DTNSRDC, CODE 2814<br>Annapolis, MD 21402 | (301) 267-2368 |
| CHASE, Vance | SIKORSKY AIRCRAFT<br>Composites Group<br>N. Main St.<br>Stratford, CT 06601 | (203) 386-7431 |
| CRITCHFIELD, Milton | DTNSRDC (Carderock)<br>Code 1730.5<br>Bethesda, MD 20084 | (202) 227-1823 |
| CROWE, Bob | NAVAL SURFACE WEAPONS CENTER<br>Code R32<br>Silver Spring, MD 20910 | (202) 394-2527 |
| CURLEY, Bob | MARTIN MARIETTA<br>102 Chesapeake Park Plaza<br>Baltimore, MD 21220 | |
| DOLOWY, Joe | DWA COMPOSITE SPECIALTIES<br>21119 Superior Street<br>Chatsworth, CA 91311 | (213) 998-1504 |
| FISHER, Mark | MARTIN MARIETTA<br>103 Chesapeake Park Plaza<br>Baltimore, MD 21220 | (301) 338-5437 |

| | | |
|---|---|---|
| FOLTZ, John | NSWC<br>Code R32<br>Silver Spring, MD 20910 | (202) 394-2019 |
| FURIO, Tony | DTNSRDC (Carderock)<br>Code 173.2<br>Bethesda, MD 20084 | (202) 227-3692<br>(contact point) |
| HANSON, Philip S. | P.H. INDUSTRIES<br>Project Engineers<br>Delray Beach, FL 33444<br>Mail address:<br>PO Box 1136<br>Bointon Beach, FL 33425 | (305) 276-9568 |
| HASKINS, Bill | NEWPORT NEWS SHIPBUILDING<br>4101 Washington Avenue<br>Newport News, VA 23607 | (804) 380-2576 |
| KENNEY, John G. | PROJECT ENGINEERS CO., INC.<br>2479 Rice Avenue<br>W. Sacramento, CA 95691 | (916) 371-5677 |
| KINNA, Marlin | SEA-62R4<br>Naval Sea Systems Cmd.<br>Washington, DC 20360 | (202) 692-9480 |
| McGOWAN, Mike | INGALLS SHIPBUILDING<br>POB 149/MS-1090-04<br>Paslagoula, MS 39567 | (601) 935-5204 |
| McLAY, Richard | GE<br>Lakeside Ave., Rm. 1320<br>Burlington, VT05402 | (802) 657-6264 |
| MISLAN, Joe | NAVSSES 073B, Bldg. 76<br>Philadelphia Naval Yard<br>Philadelphia, PA 19112 | (215) 952-7935 |
| MITTNICK, Mel | AVCO-Specialty Materials Div.<br>2 Industrial Ave.<br>Lowell, MA 01851 | (617) 454-5746 |
| NOWITSKY, Al | DWA COMPOSITE SPECIALTIES<br>21119 Superior Street<br>Chatsworth, CA 91311 | (213) 522-3017 |
| OLSTER, Elliot F. | Composite Business Dev.<br>SIKORSKY AIRCRAFT<br>North Main Street<br>Stratford, CT 06602 | (203) 386-4705 |

| | | |
|---|---|---|
| PAUL, Howard R. | DWA COMPOSITE SPECIALTIES<br>POB 276<br>Lebanon Jct., KY 40150 | (502) 833-2514 |
| REIFSNIDER, Kenneth | ESM Dept.<br>VA POLYTECHNIC INST. & ST. UNIV.<br>Blacksburg, VA 24061-4899 | (703) 961-5316 |
| SONNENBERG, Ann | CIBA-GEIGY CORPORATION<br>Composite Materials Dept.<br>Skyline Drive<br>Hawthorne, NY 10502 | (800) 431-1900 |
| STINCHCOMB, Wayne | ESM Dept.<br>VA POLYTECHNIC INST. & ST. UNIV.<br>Blacksburg, VA 24061-4899 | (703) 961-5316 |
| ZUCKERMAN, Laurie | BABCOCK & WILCOX<br>91 Stirling Ave.<br>Nuclear Equipment Division<br>Barberton, OH 44203 | (216) 860-1631 |

Appendix C.

Letter sent to Working Group Participants after the second meeting which was held at NSRDC-Annapolis

October 17, 1983

We have assembled a package of information which you will find useful for the design concept phase of the elevator door program. This package includes:

- Summary of responses to the Questionaire distributed at our second meeting in Annapolis.
- Drawings: Weapons Elevator Standard Door (non-ballistic), no. 2422325, 9 sheets.
- Drawings: Weapons Elevator Standard Door (ballistic), no. 2422385, 8 sheets.
- Drawings: Weapons Elevator Standard Door (frame and dog assy.) no. 2422326, 2 sheets.
- memo and sketches from Joe Mislan for a new family of doors for auxiliary ships.

Based on the information shared at the Annapolis meeting, the responses to the questionaire, and some recent data, we are proposing that the design concepts be formulated using the following criteria:

A. Essential Criteria
   1. water pressure
   2. weight
   3. fire

B. Other Important Criteria (no priority order implied)
   - ballistics • blast • cost • durability
   - producibility • shock

NAVSSES Working Group
10/17/83
Page 2

Please note that some changes in priority of design criteria have been made since our last meeting.

The fire tests will be conducted according to ASTM Standard 119-81: "Fire Tests of Building Construction and Materials". The doors should be designed to survive for 30 minutes under the temperature conditions provided in an earlier distribution. The shock criteria are less well defined but will allow some deformation of the door provided the door does not become unuseful and can be readily repaired.

We are setting a submittal date of 1 December, 1983 for the design concepts (slipped from the 31 October date). Please send your design concepts and any other supporting information to us at Va Tech. A third meeting of the Working Group will be scheduled before the Christmas holidays.

Lastly, Joe Mislan has provided some recent information on a new family of doors being considered by the Navy. A copy of Joe's note is included for your consideration. Note that paragraph 6 provides an opportunity to submit to the Navy a proposal with suggestions on materials and general construction.

We are working to have information on funding for the weapons elevator door program ready to present at the third meeting. Thank you for your continuing interest in this program. Please call us if we can help you.

Sincerely,

W. W. Stinchcomb
Professor
ESM Department

K. L. Reifsnider
Reynolds Metals Professor
ESM Department

enclosures

WWS; KLR/bw

C3

Working Group
Application of Composite Materials
to Naval Weapons Systems

Response to Questionaire distributed at the Annapolis meeting

1. Organizations indicating written interest in continued involvement in the elevator door program.

   - AVCO
   - BABCOCK AND WILCOX (B&W)
   - CABOT
   - DAVID TAYLOR - CARDEROCK (DTNSRDC-C)
   - GENERAL ELECTRIC (GE)
   - PROJECT ENGINEERS CO. (PEC)
   - TRE MARINE PRODUCTS (TRE)

2. Additional information needed.

   • Overall program schedule • Estimated program funding • Funding • R&D dollars • RFQ • Ballistics requirements • Number of doors to be purchased over five year period • Time

3. Organizations wanting to be considered as a supplier of a 2 ft. by 2 ft. demonstration item.

   • AVCO • CABOT (Material) • PEC
   • B&W • GE • TRE

4. Organizations wanting to submit design concepts.

   • AVCO (Funding needed) • GE (Funding needed) • TRE
   • B&W • PEC

5. Design criteria*.

A. Essential criteria (in original priority order)

1. water pressure 2. blast 3. fire 4. shock

B. Other important criteria (no priority order implied)

- Ballistics -- to include fragmentation characteristics
- Cost -- life cycle cost to include initial cost, repairability, maintainability, interchangeability
- Durability -- to include failure modes, corrosion resistance, sealing, and leakage
- Producibility -- to include availability of materials and manufacturing/fabrication technology
- Weight

6. Submittal of design concepts.

The submittal date will slip beyond 31 October, 1983.

7. Organizations interested in other shipboard structures.

- AVCO
- B&W
- CABOT
- DTNSRDC-C
- GE
- PEC
- TRE

8. Organizations with test facilities available **

- AVCO (fire, thermal, mechanical, shock, vibration, QC)
- B&W (pressure, blast, fire)
- DTNSRDC
- GE
- PEC (bending, shear, weld pull)
- TRE (mechanical, structural, metallurgical)

* See letter for revised ordering of design criterion.

** Details are on file at Va Tech.

## Appendix D.

## Evaluation of Design Concepts

### Materials System Evaluation

| Organization | Weight Saving | Physical Properties | Workability Producibility | Adaptability | Supply Sources | Overall Concept |
|---|---|---|---|---|---|---|
| Sikorsky | A | A | A | A | B | A |
| DWA | B - lacks data | C | C - more data needed | A | C | C |
| TRE | B | A | B | B | C | A |
| Ingalls | | | | | | |
| GE | A | C | A | B | A | B |
| B&W | B - lacks data | B | C | B | A | B |

A - acceptable for
B - limited compliance
C - marginal compliance
D - unacceptable
U - undefined

D2

## Design Evaluation

| Organization | Water Damage Control | Level | Type | Overpressure | Fire | Corrosion | Maintainability | Shock |
|---|---|---|---|---|---|---|---|---|
| Sikorsky | B - lacks dimension data | U | U | B - lacks detailed data | A | A | B - some additional protective capability needed | U |
| DWA | U | C | C | U | B | U | B | U |
| TRE | A | C | C | A | A | A | B | A |
| Ingalls | | | | | | | | |
| GE | B | U | U | C | D | A | A | A |
| B&W | B | C | C | B | A | B | C | U |

A - acceptable for all applications
B - limited compliance
C - marginal compliance
D - unacceptable
U - undefined

E1

## Appendix E.

### Physical Properties of Lightweight Door Panels

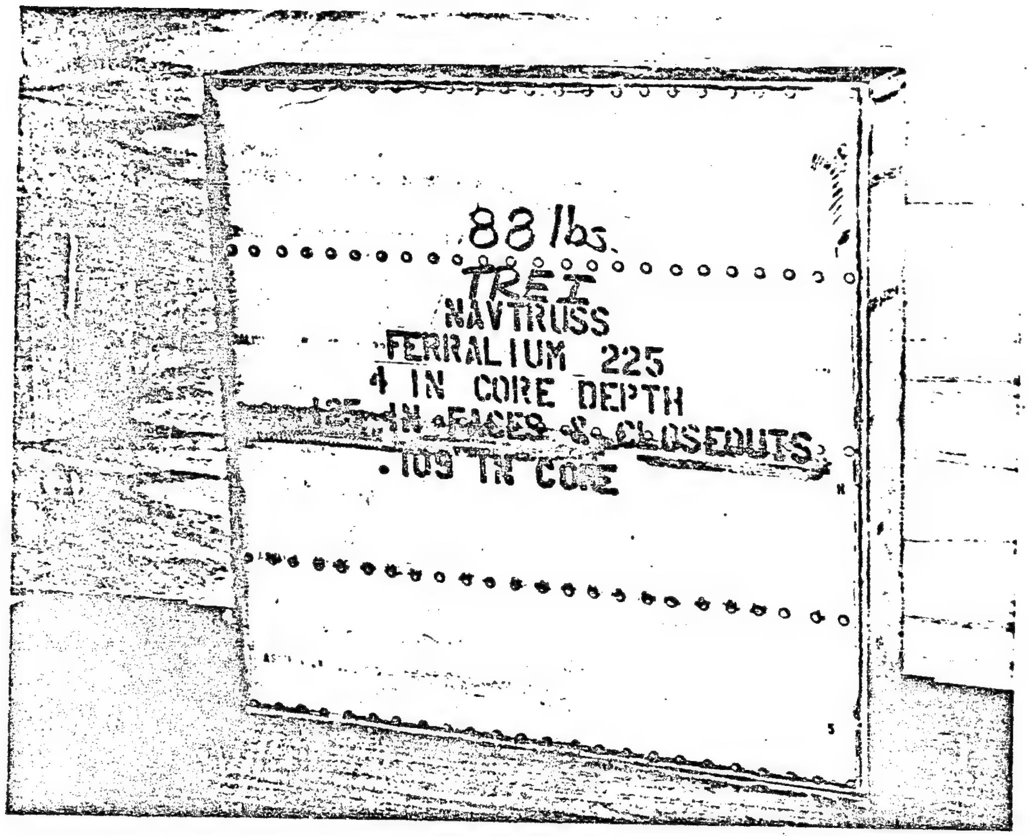
| Panel | Dimensions (inches) (Length x width x thickness) | Weight (lbs) | Volume Density* (lbs/ft$^3$) | Areal Density** (lbs/ft$^2$) |
|---|---|---|---|---|
| Martin I (coated) | 24.813 x 24.813 x 7.750 | 123.75 | 44.8 | 28.9 |
| Martin II | 24.625 x 24.688 x 7.688 | 118.75 | 43.9 | 28.1 |
| TRE I | 24.250 x 24.250 x 4.313 | 88.0 | 60.0 | 21.5 |
| TRE II | 24.188 x 24.188 x 4.250 | 87.0 | 60.5 | 21.4 |
| DWA | 25.063 x 16.125 x 3.750 | 36.2 | 41.3 | 12.9 |

* Volume density calculated as:

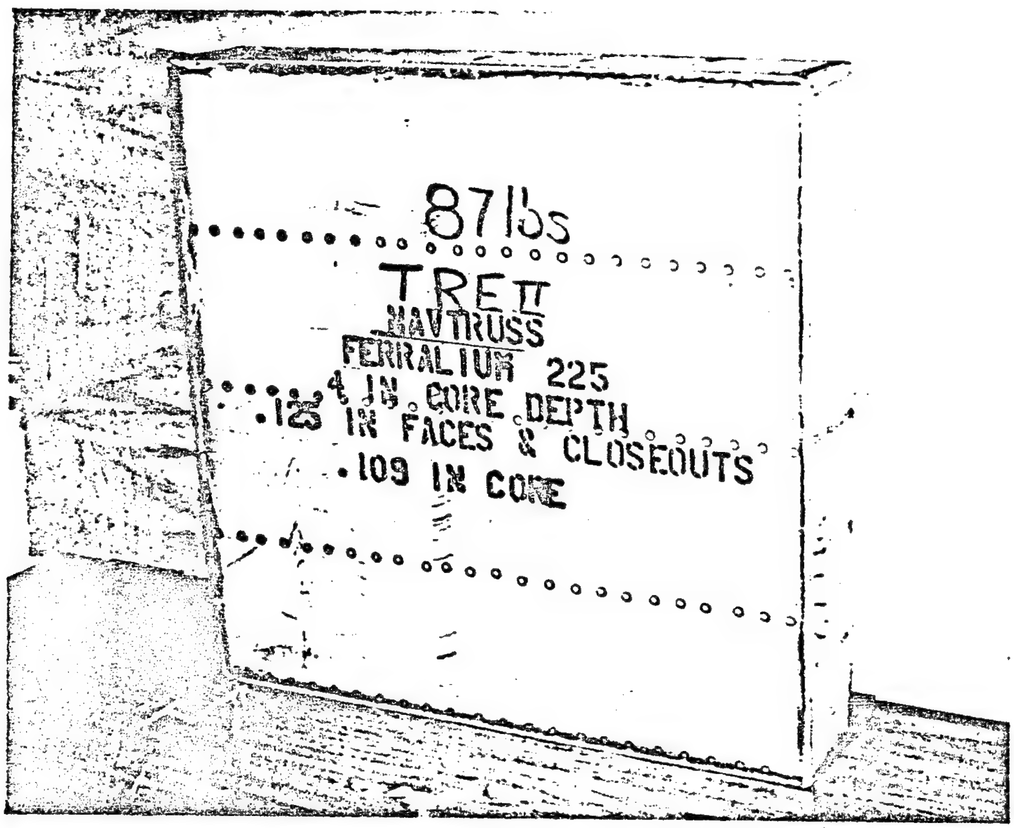
$$\frac{\text{Length x width x thickness}}{\text{weight x 1728 in}^3/\text{ft}^3}$$

** Areal density calculated as:

$$\frac{\text{length x width}}{\text{weight x 144 in}^2/\text{ft}^2}$$

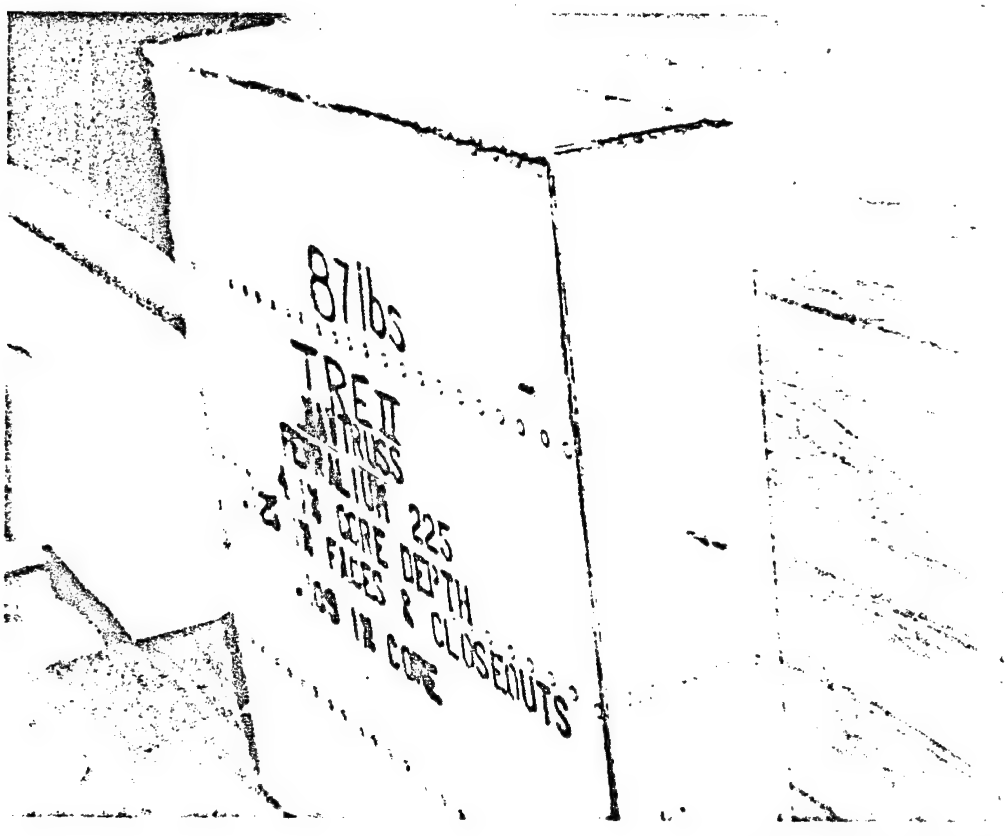



Test panel TRE I with corrugated core.

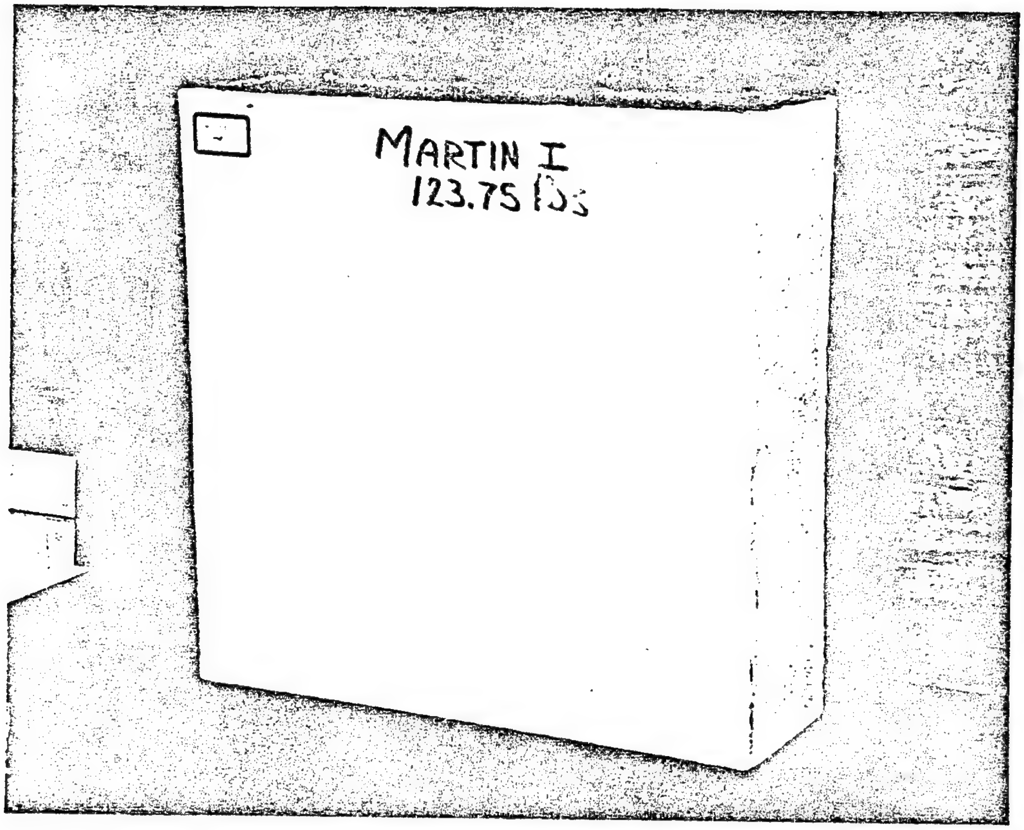



Test panel TRE II with corrugated core.

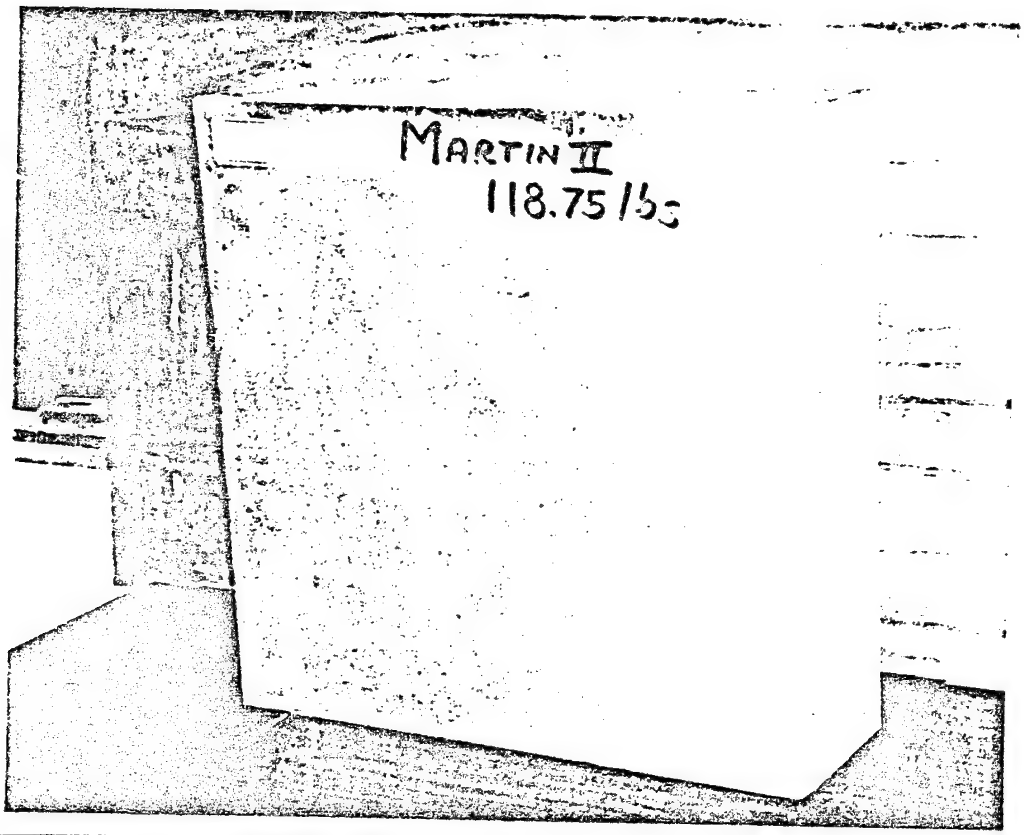
E4



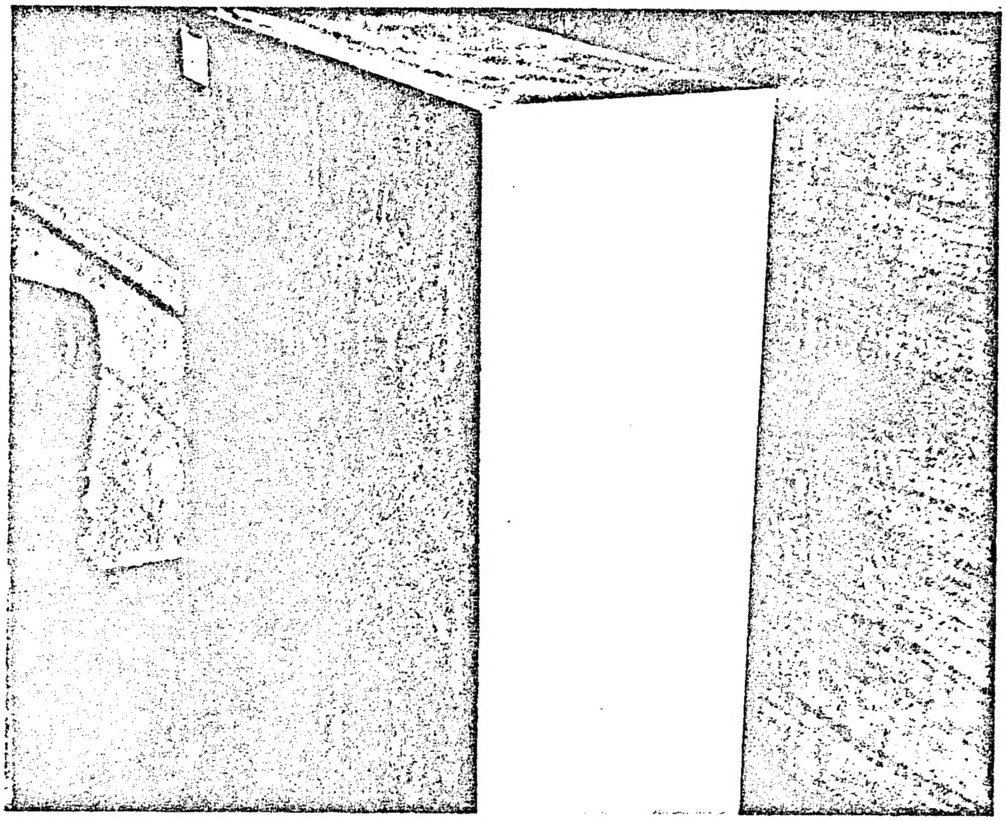

Edge of panel TRE II showing construction of closeouts.



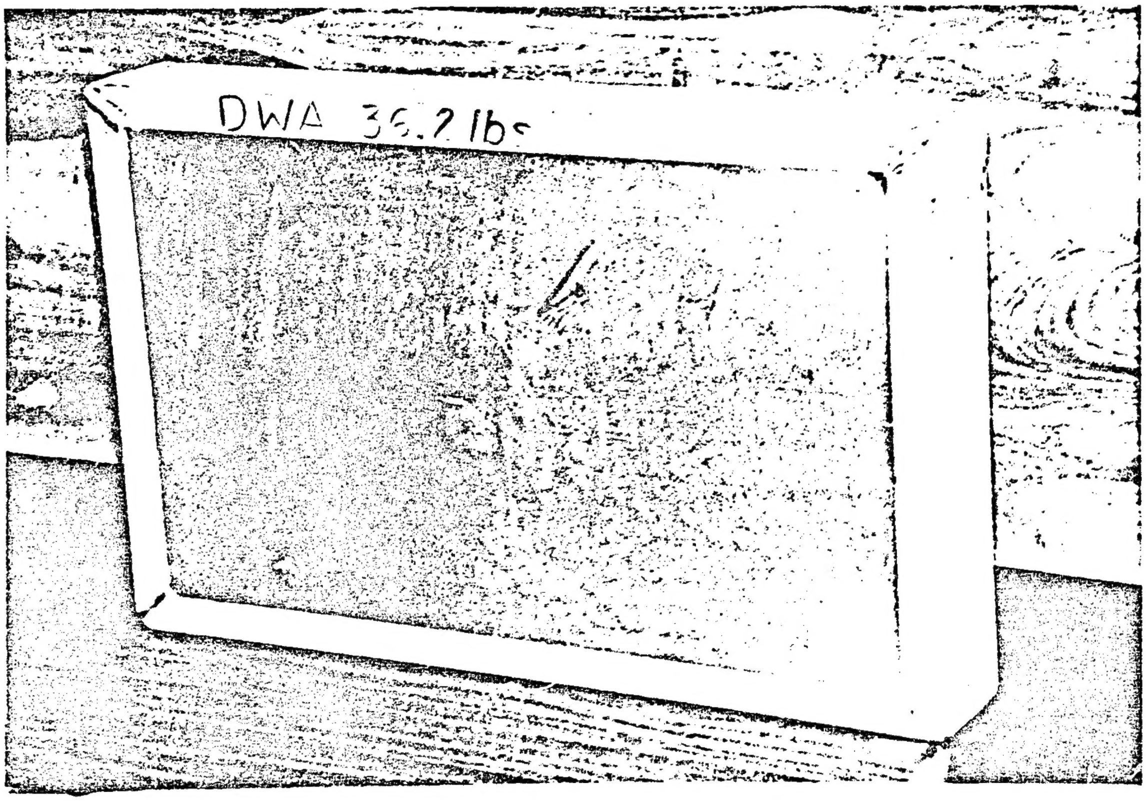

Test panel Martin I with honeycomb core and protective coating.




Test panel Martin II with honeycomb core.



Edge of panel Martin II showing ballistic face plate .
Similar plate on Martin I panel.




DWA test panel with egg- crate core.

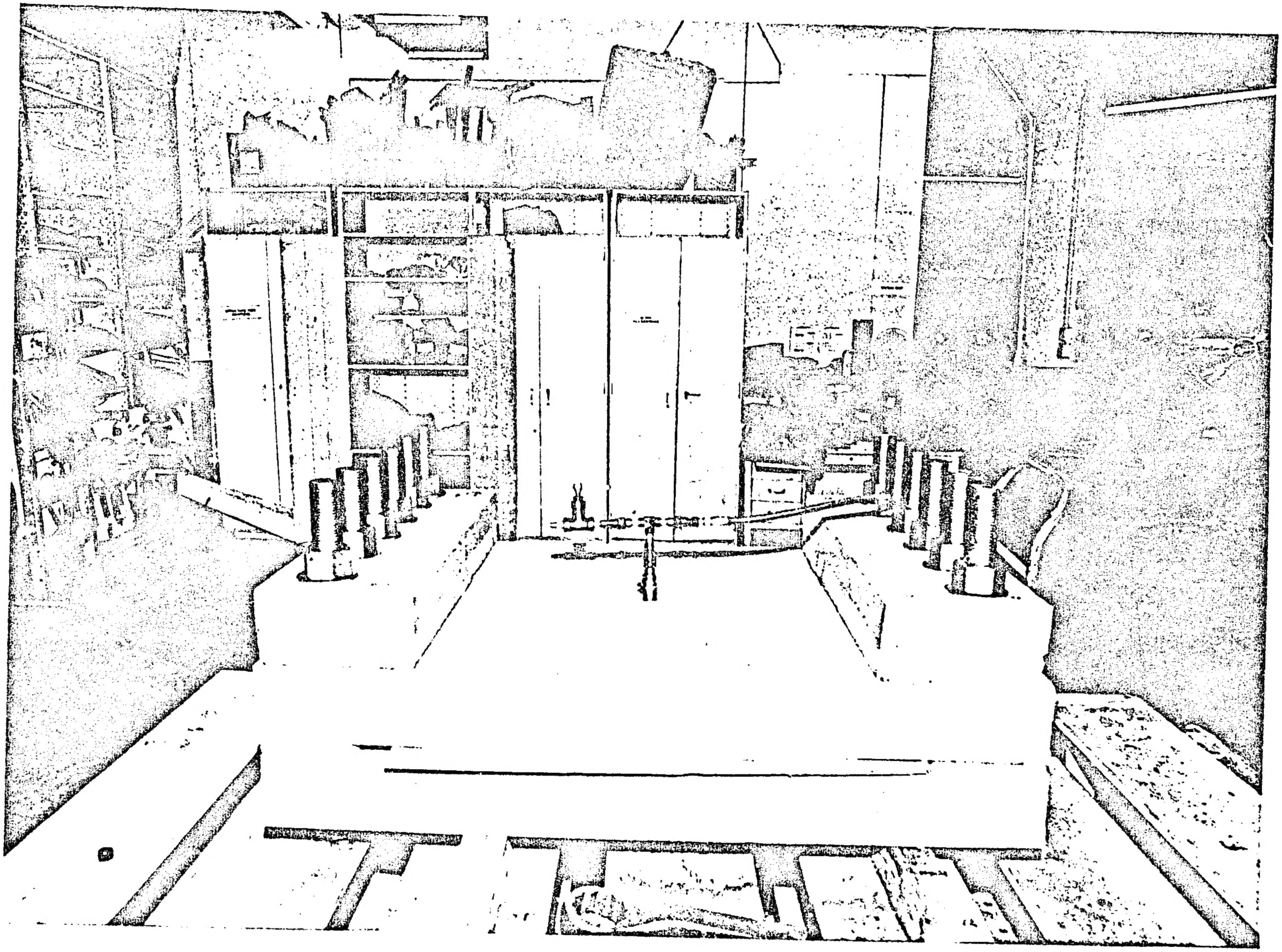


Fig. 1a Panel Test Fixture in the Structural Test Laboratory at Martin Marietta Aerospace, Baltimore, Maryland.

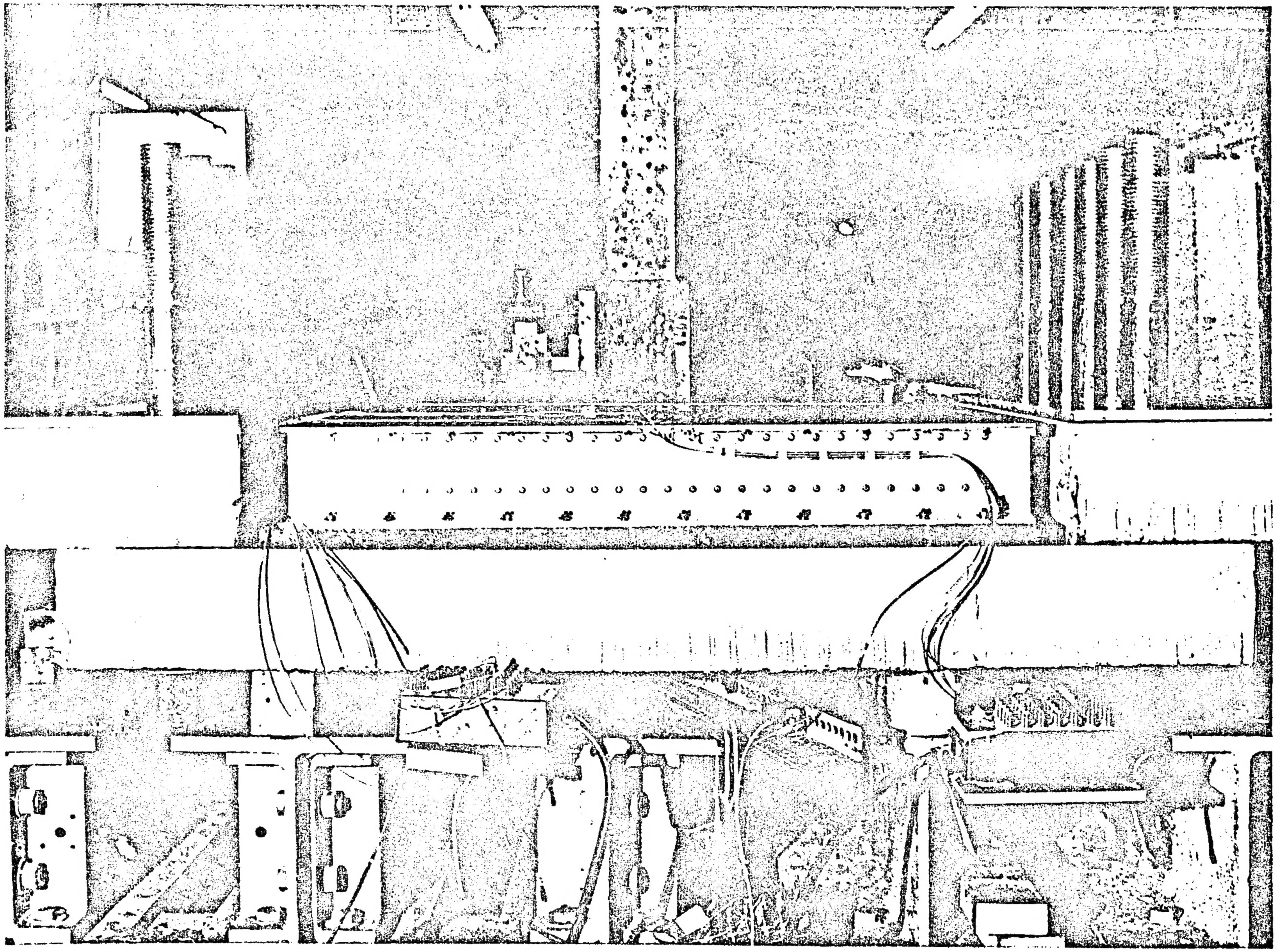


Fig. 1b  Close-up of the Panel Test Facility with platen removed to show test panel and strain gage instrumentation.